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98-153

March 5, 2001

BY HAND

Ms. Magalie R. Salas
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: Written Ex Parte Presentation
ET Docket No. 98-~~253~~ 153

Dear Ms. Salas:

On behalf of my client QUALCOMM Incorporated ("QUALCOMM"), this is to provide the Commission and the staff of the Office of Engineering & Technology with the attached results of a series of laboratory tests recently conducted by QUALCOMM to assess the impact of ultra-wideband ("UWB") emissions on PCS phones. QUALCOMM's tests showed that close proximity of UWB devices to wireless phones will degrade the phones' equivalent noise figure to the extent of rendering their operation useless, especially in marginal coverage areas.

Consequently, QUALCOMM urges the Commission not to issue rules in this proceeding authorizing any UWB operations until it has a complete record containing reliable, suitable, and sufficient testing and analysis of the potential for interference from UWB devices.

Sincerely yours,

Dean R. Brenner
Attorney for QUALCOMM Incorporated

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cc: Chairman Michael Powell
Commissioner Susan Ness
Commissioner Gloria Tristani
Commissioner Harold Furchtgott-Roth
Bruce Franca
Rebecca Dorch
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John Reed
Thomas Sugrue
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Before The
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MAR 5 2001

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In The Matter Of	)	
	)	ET Docket No. 98-153
Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmissions Systems	)	

REPORT OF QUALCOMM INCORPORATED

Dr. Samir S. Soliman
Vice President- Technology
QUALCOMM Incorporated
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1. Executive Summary

QUALCOMM recently conducted a series of laboratory tests to assess the impact of ultra-wideband (UWB) emission on PCS phones. This investigation focused on assessing UWB proponent's claims that the technology is able to share the spectrum with existing users with no or minimal interference. QUALCOMM's tests have shown that close proximity of UWB devices to wireless phones will degrade the phones' equivalent noise figure to the extent of rendering their operation useless, especially in marginal coverage areas. The Commission should not act in this proceeding until it has a complete record containing reliable, suitable, and sufficient testing and analysis of the potential for interference from UWB devices.

2. Introduction

QUALCOMM is a worldwide leader in developing and delivering innovative digital wireless communications products and services based on the Company's Code Division Multiple Access (CDMA) digital technology. Its corporate goal is to maintain the voice quality superiority and the spectral efficiency advantages of the CDMA products.

QUALCOMM joins others in their considerable concern for the integrity of existing and licensed communications and navigation systems in cases where Ultra Wideband devices are allowed to co-exist. Many communication and navigation systems depend upon the detection of weak signals for their operation. QUALCOMM has developed enhanced versions of GPS sensors integrated with their phone ASICS. The interference from UWB devices will have a severe impact on the performance of these enhanced GPS sensors. QUALCOMM gpsOne™ uses signals from GPS satellites to determine the position of E911 callers in in-door and in urban canyons environments.

The major differences between UWB and other unlicensed devices include:

(1) UWB devices emit significant power over a large portion of the spectrum and may generate multiple spectral peaks over a very large range of frequencies.
(2) UWB pulses will have peak powers greatly exceed average power.
(3) UWB applications, such as data networking and collision avoidance radar, will lead to a proliferation of large number of UWB transmitters.

Essentially, a UWB communications system trades pulse shortness (gaining a high signal/symbol rate) in exchange for two other variables: bandwidth (which becomes wider) and S/N (which is reduced). Greater bandwidth usage requires FCC approval thus the FCC's Notice of Proposed Rulemaking (NPRM). A lower S/N requires signal averaging, which then lowers the data rate. Lowering the symbol rate defeats the purpose of achieving high data rate. Of course, these trade-offs can be to some extent alleviated by transmitting pulses, the lowest frequency components of which are higher than FCC Part 15 bands (above ~3 GHz) or by using higher power (if permitted and non-interfering). However, both of these strategies are also available to conventional, non-interfering wireless communications systems. As in any communication system, the UWB system designer must balance the trade-offs among bandwidth efficiency, low peak power, low complexity, quality and reliability of the service.

3. Analytical Results

This section discusses the analytical procedures used to determine the maximum permitted EIRP level and minimum separation distance to ensure compatibility between UWB devices and other licensed wireless systems. The PCS system under study operates above 1000 MHz. Therefore, the EIRP limit was based on the emission limit of 500 μV/m or an equivalent EIRP limit equal to -41.3 dBm/MHz (RMS).

While CDMA systems have inherent spreading gain that can be used to mitigate this effect, the systems are designed to use this spreading gain to combat intrinsic multiple access interference. Phones are designed with fading margin in mind. It is a fundamental lack of understanding of the basic principles of CDMA to assume that this gain can be used to mitigate un-intentional in-band interference. The system may continue to perform well in the face of UWB interference, but at the expense of reduced limit margin. This reduction in margin may not be noticeable in a static case, but would be very noticeable in a fading scenario.

The impact of UWB devices on PCS phones could be even greater than the impact on GPS because of the antenna system. In the case of GPS, the gain of the receiving antenna is much smaller in the direction of the UWB source. In the case of the PCS phone, the gain of the receiving antenna on the horizon is higher in the direction of the UWB source. The actual difference depends upon the antenna used.

When assessing the impact of UWB on PCS, there are a number of approaches that can be taken:

(1) Evaluating the impact of interference on a generic receiver (antenna gain and receiver noise figure).
(2) Evaluating the impact of interference on specific types of receivers (more details on the victim receiver are needed such as modulation and coding).
(3) Evaluating the impact of interference on a specific system (details of the system are needed such as power control, handoff etc.).

Before analyzing the impact on a generic receiver, we will address the issue of the propagation characteristics of a wideband signal.

3.1 Wideband Signal Path Loss

Suppose that a transmitted power P_t in watts is used to send a wideband signal with bandwidth B Hz. The power spectrum of each frequency component of the signal over the bandwidth B is S(f). The relation between the power and the power spectrum is

$$P_t = \int_{f_o - B/2}^{f_o + B/2} S(f)\, df \tag{3-1}$$

The Poynting vector (transmitted power density) is

$$U_t = \frac{P_t}{4\pi r^2} \tag{3-2}$$

The received signal can be expressed as

$$P_r = U_t\, C(r,f)\, A_e(f) \tag{3-3}$$

where C(r,f) is the channel propagation loss and $A_e(f) = G/4\pi\lambda^2$ is the effective aperture of the receiving antenna. For line-of-sight propagation, C(r,f) = 1 and

$$P_r = \frac{c^2 G}{(4\pi r)^2} \int_{f_o - B/2}^{f_o + B/2} S(f)/f^2\, df \tag{3-4}$$

Assuming a white noise spectrum, i.e., S(f) = k/B

$$P_r = \frac{k c^2 G}{(4\pi r)^2} \frac{1}{[f_o^2 - (B/2)^2]} \tag{3-5}$$

The narrowband line of sight received power is

$$P_r = \frac{kc^2 G}{(4\pi r)^2} \frac{1}{f_o^2} \qquad (3\text{-}6)$$

From Eqs. (3-5) and (3-6), the ratio between a wideband and narrow band path losses is

$$\rho_{LOS} = \frac{1}{1 - (x/2)^2} \qquad (3\text{-}7)$$

where x is the fraction bandwidth = B/f_0. Figure 3.1 depicts the deviation of path loss from narrowband signals as a function of the fractional bandwidth. From the above development we conclude that a narrowband propagation model can be applied for ultra wideband signals.

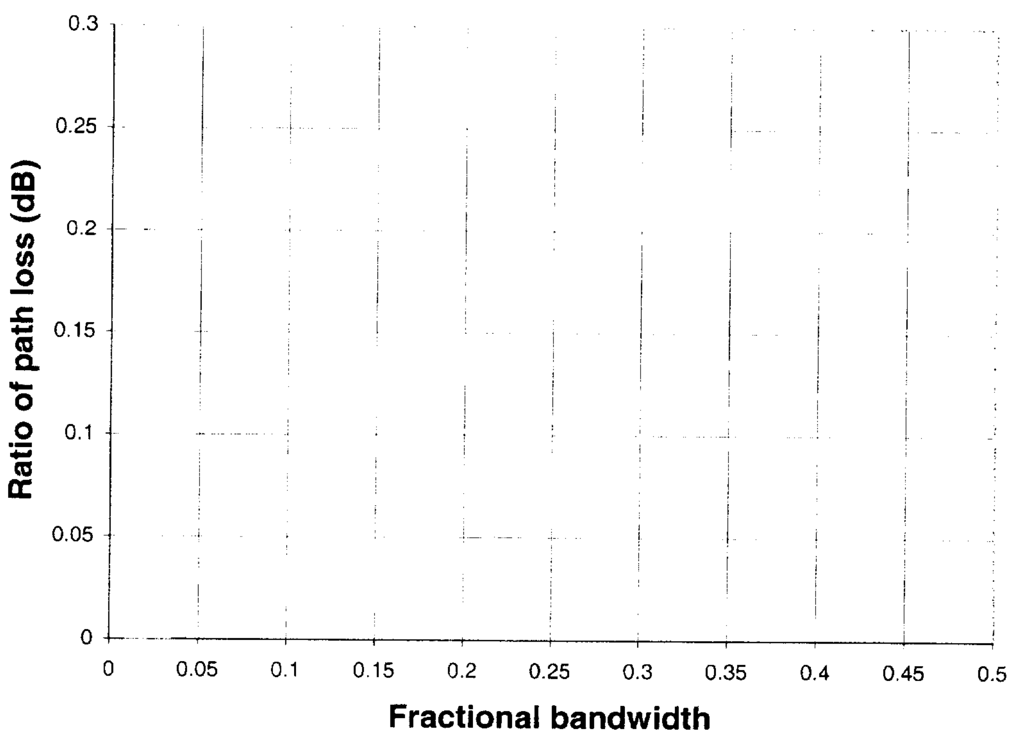

Figure 3.1: Path loss for wideband signals

In order to determine the degree to which the radios will cause harmful interference to each other, a number of assumptions are necessary. It is difficult, if not impossible, to define a typical network topology. User scenarios, and even indoor propagation models, can be rather subjective. But, by using some reasonable assumptions, analysis of the interference caused by co-location of the two radio types can proceed.

Assumptions include:

(1) A network topology and user density
(2) Propagation model
(3) Network traffic loads for UWB

The degree of interference experienced in any installation is dependent on local propagation conditions, the density of UWB piconet, and UWB loading and utilization models. For this analysis, it is assumed that there is one UWB piconet co-located within the same office or room. The UWB piconet consists of two or more BT devices which are capable of establishing at least one point-to-point link. The number of UWB piconets which are actively transmitting at any point in time is highly dependent on usage scenarios. These devices are limited to –41.2.dBm transmit power (maximum for Class B Part 15 devices).

There are two likely scenarios for UWB deployment are: indoor use as in the Bluetooth scenario and outdoor uses, such as in vehicle collision avoidance. For indoor use, typical and expected UWB equipped devices which might be found in the home or office include:

(1) Desktop PCs
(2) Palmtops /laptops
(3) Local printers
(4) Indoor cell phone coverage extension

The degree to which a CDMA phone is susceptible to interference from a nearby UWB device is dependent on the strength of the CDMA signal. The weaker the CDMA signal, the more susceptible it is to the interference from the UWB devices.

A measure of the performance of the wireless device in both voice and data modes is the energy-per-bit to noise power density

$$\frac{E_b}{N_o} = \frac{\eta P_o}{N_{th} + U + P_{mp} + \sum_i P_i} P_g$$

where:

P_o = Power received from the desired cell

η = Percentage of power allocated to the traffic channel

N_{th} = Thermal noise

U = UWB noise

P_{mp} = Other traffic channel noise due to multipath

$\sum_i P_i$ = Other cells interference

P_g = Processing (spreading) gain

The exact values of the noise components, except for the thermal noise, are highly dependent on the geometry (location of the wireless device in the network).

3.2 Interference Analysis Using Generic Receiver

The objective is to calculate isolation in dB. Isolation may be converted into a physical separation using path loss formula. It is considered as a worst case analysis and produces a spectrally inefficient result. It assumes single interference transmitting at maximum power to guard against the worst case scenario. The victim receiver degradation is measured in terms of noise figure degradation. Interference power in the victim receiver bandwidth is given by

$$I = P_{UWB} + G_T - L_p + G_R - L_R \tag{3-8}$$

where:

I = interfering signal power level at the receiver input

P_{UWB} = radiated interfering signal power level of the UWB transmitter within the receiver bandwidth of the victim receiver bandwidth in dBm

G_T = UWB transmitter antenna gain in dBi

L_p = propagation loss between the UWB transmitter and the victim receiver in dB

G_R = victim receiver antenna gain in dBi

L_R = cable/insertion loss of the victim receiver in dB

The relationship between path loss and distance is given by

$$L_p = 20\log(d) + 20\log(f) + 28.15 + L_{adjust} \quad (3\text{-}9)$$

where:
d = distance separation between transmitter and receiver in km
f = frequency in MHz.

L_{adjust} = adjustment factor to account for non-line of sight effects such as clutter.

Even at its relatively low transmit level, the emissions from UWB transmitters that are in the victim receiver's passband can be large enough to harm the normal operation of the mobile. If we use a 1 dB rise in the noise floor as a criterion, then the interference power should be 5.85 dB below the noise floor. The general radiated emission limit for frequencies above 900 MHz is set to 500 μv/m at a distance of 3 meters measured in a 1 MHz bandwidth. This can be converted into dBm using the following formula

$$P_{dBm} = 10\log(E_{\mu v/m}) - 20\log(f_{MHz}) - 73 \quad (3\text{-}10)$$

Equations (3-9) and (3-10) allow conversion from the FCC's Part 15 emission value into a power measurement in dBm into a dipole transmitting antenna

$$P_{dBm} = 20\log(E_{\mu v/m}) + 20\log(d_{km}) - 44.8 \quad (3\text{-}11)$$

With E = 500 μv/m and r = 0.003 km, the emission limit is -41.2 dBm measured in 1 MHz bandwidth by an isotropic antenna.

Table 3.1: **Link budget analysis: UWB impact on PCS mobiles**

Parameter	Value	Units	Equation
Frequency	1900	MHz	f
KT	-174	dBm/Hz	KT
Victim bandwidth	1.25	MHz	B
Victim noise figure	8	dB	NF
Noise floor	-105	dBm	N=Kt + B + NF
Allowed Int. level	-111	dBm	I = -N –6
UWB I in 1.25 MHz	-40.22	dBm	P = -41.22 + 10 log(1.25)
UWB transmitter gain	0	dBi	GT
Victim rec. gain	-3	dBi	GR
Victim rec. line loss	2	dB	LR
Path loss required	64.78	dB	Lp= P + GT +GR – LR – I
Minimum distance	35	m	20 log(d) = Lp - 20 log(f) - 28.1

Figure 3.2 depicts the degrdation in the noise figure of a general receiver with noise figure of 8 dB and antenna gain of 0 dBi. The UWB transmitter antenna gain is 0 dBi.

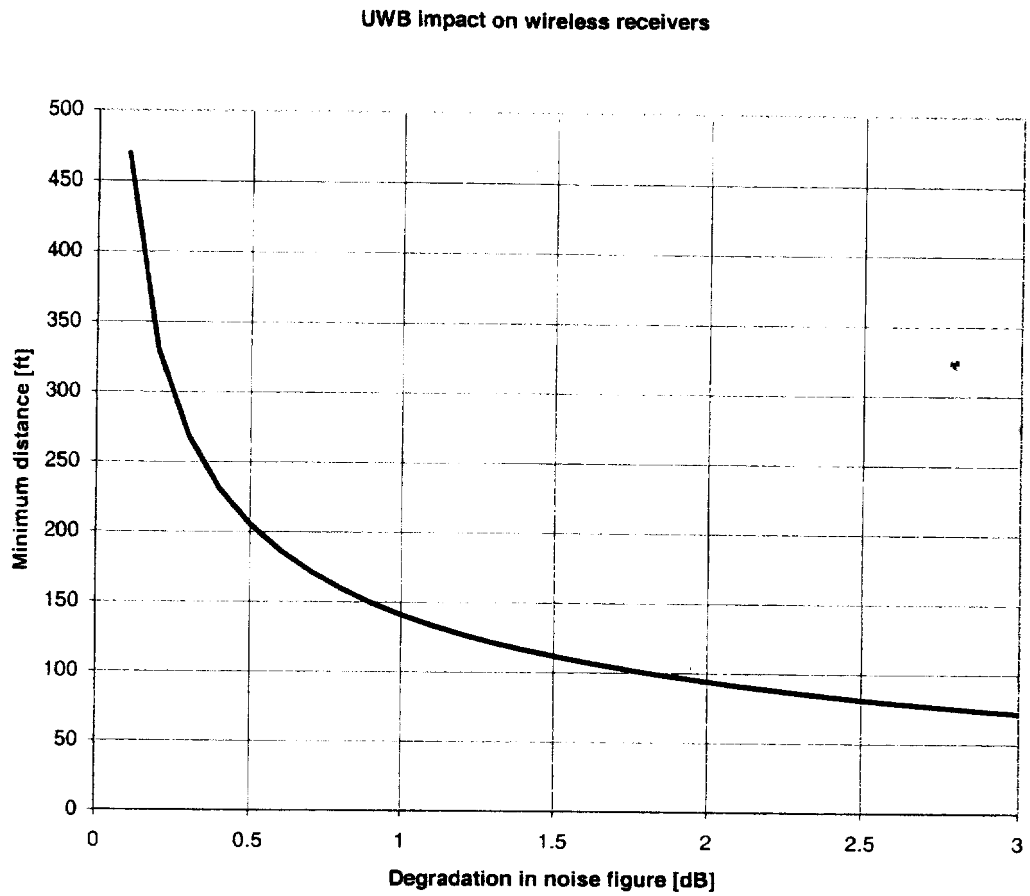

Figure 3.2: Impact of UWB source on general receiver

Figure 3.3 depicts the degradation in noise figure of general receivers for different receiver noise figures for a line-of-sight scenario with receiver antenna gain of 0 dBi and UWB transmitter antenna gain of 0 dBi.

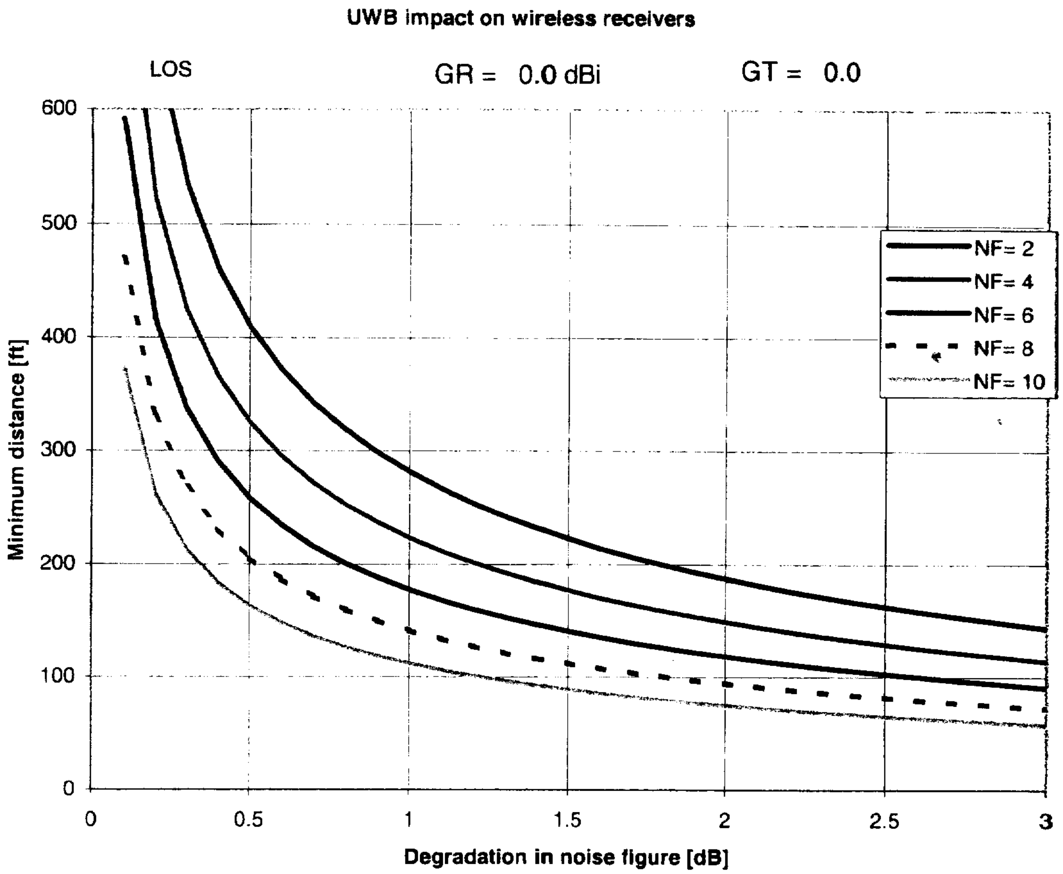

Figure 3.3: Impact of UWB source on general receivers with different NF for LOS scenario

Figure 3.4 is for the non-line-of-sight scenario. The propagation constant used in Figure 3.4 is n – 3.3.

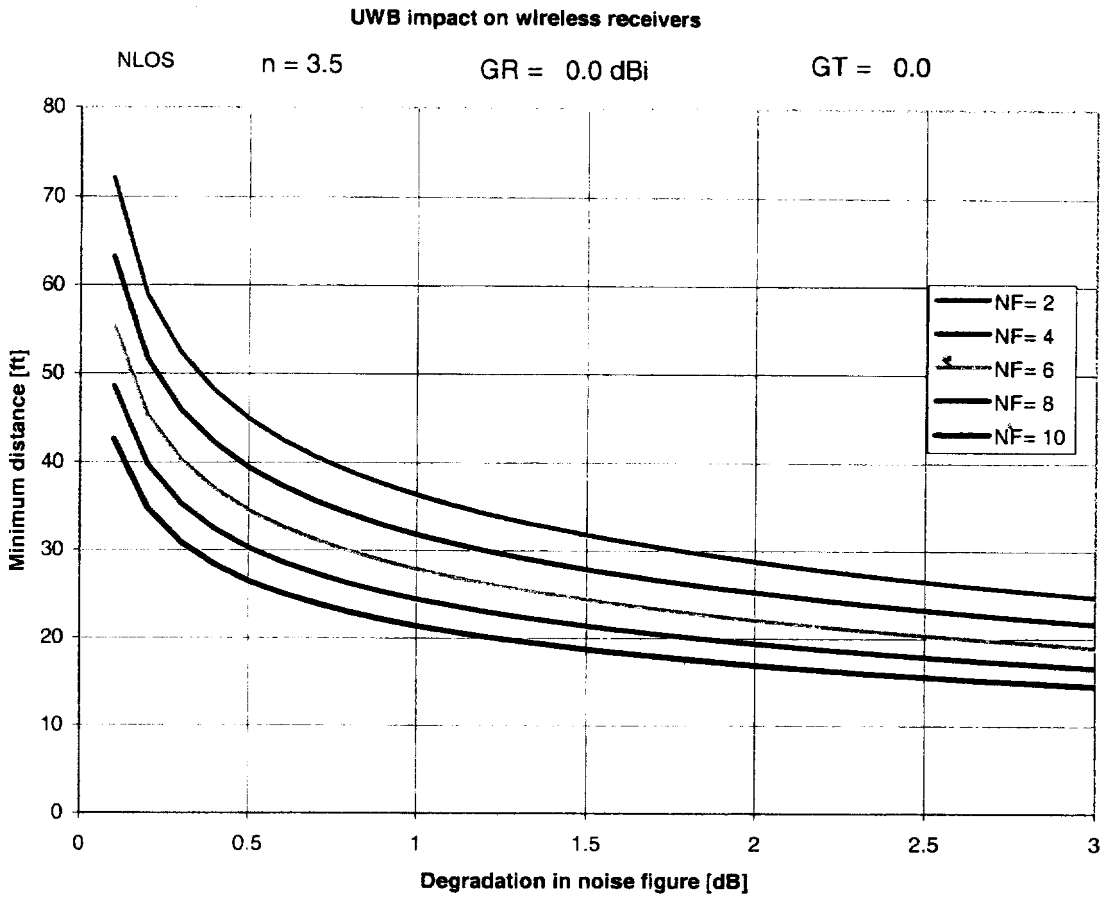

Figure 3.4: Impact of UWB source on general receivers with different NF for NLOS scenario

The degradation in the wireless device noise figure can be translated into shrink in coverage, which in turn can be translated into increase in the number of base stations required. It can be shown that for a propagation exponent *n*, the number of base stations required in the case of UWB interference is

$$N_2 = 10^{\Delta/(5n)} N_1 \tag{3-12}$$

where Δ is the degradation in noise figure, N_2 is the number of base station in the presence of interference and N_1 id the number of base station in the absence of interference.

Figure 3.5 depicts the % increase in the number of base stations as a function of the degradation in noise figure for different propagation exponents.

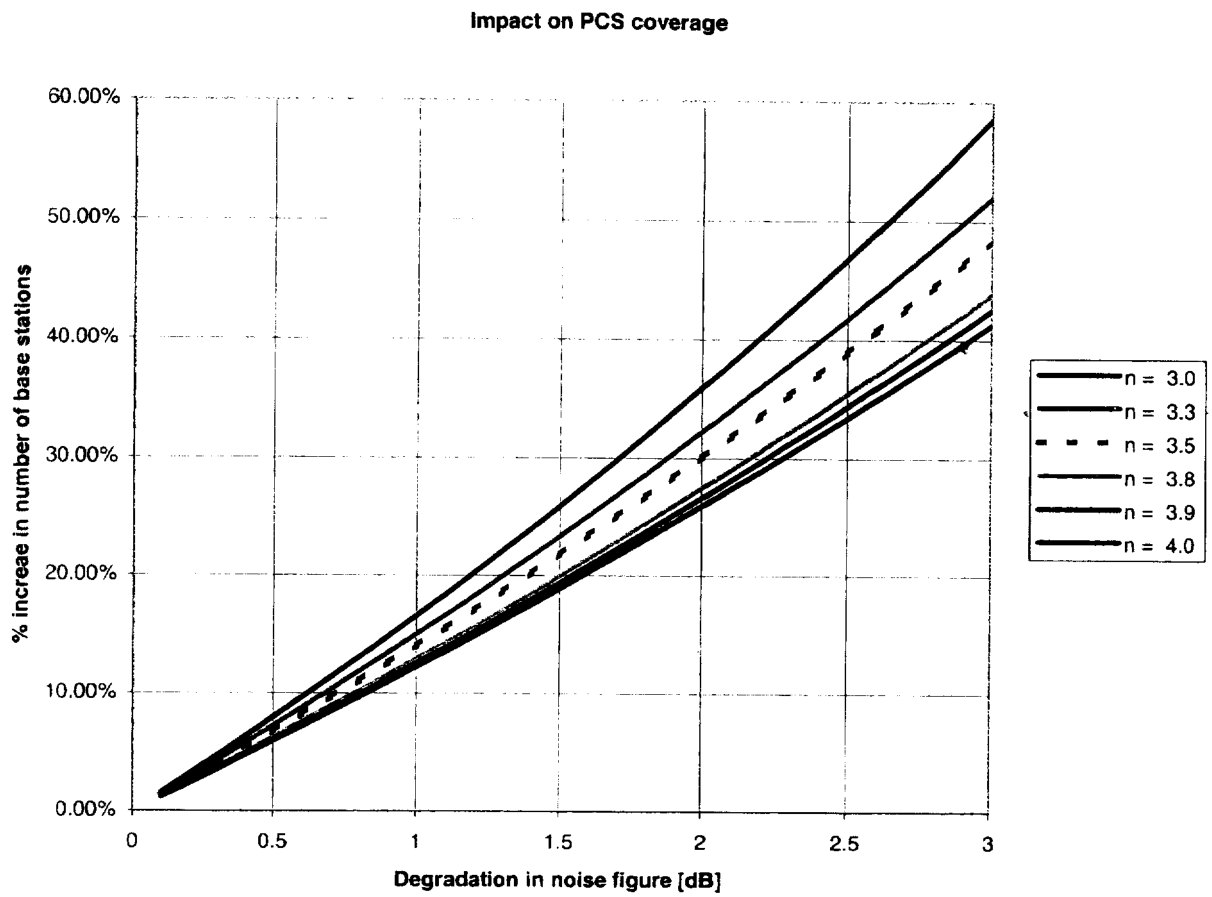

Figure 3.5: Impact of UWB source on general receivers with different NF for NLOS scenario

The effect of aggregate interference will depend on a number of factors, including the characteristics of the UWB devices, the characteristics of victim receivers, and the density of UWB devices. QUALCOMM is in the process of analyzing the impact of aggregate UWB interference on PCS phones and will report on these results in the near future.

4. Laboratory Measurements

QUALCOMM recently conducted a series of laboratory testes to assess the impact of UWB emission on PCS phones. The focus of this investigation was to assess the UWB proponent's claims that the technology is able to share the spectrum with existing users without serious interference. The assessment of that claim is critical to decisions regarding the deployment, and potential ubiquitous use of UWB devices for both communications and sensing.

4.1 UWB Device Used in Testing

The time-domain structure of UWB signals are such that emission bandwidths are very large and could overlap many licensed wireless bands. The output of the pulse generator captured by the Sampling Oscilloscope (TDS8000) is shown in Figure 4.1.

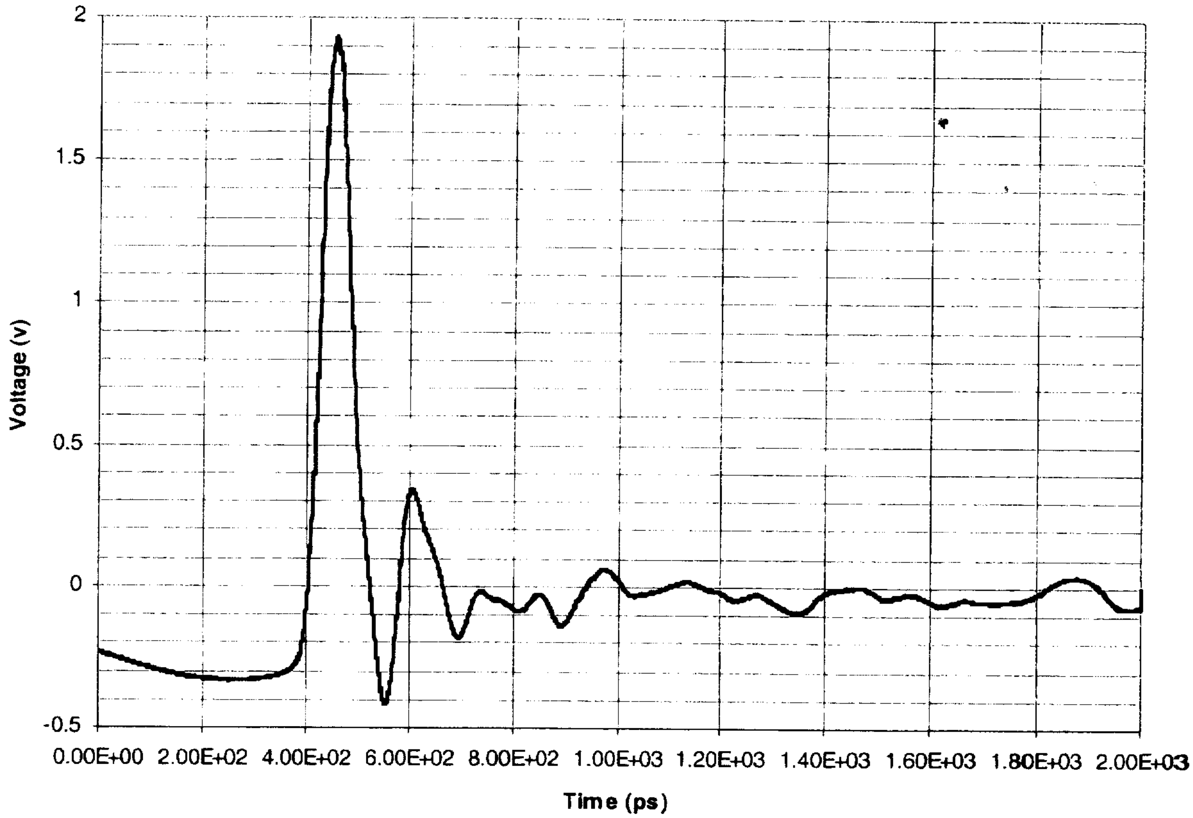

Figure 4.1: Pulse shape

4.2 Measuring Instruments

The accuracy of laboratory testing of UWB systems for interference is dependent upon the accuracy of the laboratory equipment used. In the section, we list the equipment used during the laboratory testing. All instruments used are commercial off-the-self test equipment.

4.2.1 Wideband Spectrum Analyzer

HP8563E spectrum analyzer was used for the wideband measurements.

4.2.2 Mobile Station Tester (HP 8924C)

The base station signal was generated by a HP 8924C Base Station Emulator (BSE) which is a mobile test instrument capable of generating signals emulating two sectors of a CDMA base station compliant with the IS-95 Air Interface Standard.
The test mobile was an off-the-shelf QUALCOMM model QCP-1960 handset, complaint with the IS-95 CDMA Air Interface Standard. The phone was programmed/tuned to receive and transmit on PCS channels 100 and 600.

The BSE was configured to transmit on PCS channel 600 for tests using PRFs of 10 and 17.5 MHz and PCS channel 100 for tests using a PRF of 15 MHz. The mobile was connected to a laptop computer using a custom cable. The performance of the phone and the progress of a call were monitored using a CDMA Air Interface Tester (CAIT) which is a diagnostic software tool that runs on the computer.

Calls were made to the mobile by the BSE and were standard 8k-loop-back calls (Service Option 2) with traffic frame rate set to full frame. On this type of a call, the BSE sends full rate frames to the mobile and the phone echoes the frames it receives from the base station. The BSE counts the number of frames it receives back from the mobile that do not match the frames that it originally transmitted. The frame error rate is then calculated by the BSE as a percentage of frames received in error out of 6000 frames which correspond to industry standards for a 2-minute call period.

The BSE was setup as a two-sector base station with handoff prohibited. The individual Walsh channel percentage of the total transmitted power is listed in Table 4.1.

Table 4.1: Total transmitted power

Parameter	Sector A	Sector B
Sector Total Power (dBm)	-40	-40
Pilot Channel (dB)	-11	-12
Paging Channel (dB)	-16	N/A
Sync Channel (dB)	-12	N/A
Traffic (dB)	-16.0	-16.0
OCNS (dB)	-0.9243	-0.4120
PN Offset	12	36
PCS Channel (PRF 10, 17.5 MHz)	600	600
PCS Channel (PRF 15 MHz)	100	100

4.3 UWB Pulse Generator Module

QUALCOMM contacted several UWB companies in order to buy or borrow an UWB pulse generator module. All the companies contacted declined the request due to lack of resources. QUALACOMM subsequently decided to buy the HL9200 pulse generator module from HyperLabs Inc. The HL9200 has the following listed features:

Rise time: 35 pico seconds
Fall time: 50 pico seconds
Duration: 70 pico seconds
Output Amplitude: 2 V minimum
Trigger rate: DC to 20 MHz
Trigger input: 0 to +5, Schmitt Trigger at +2V

4.3.1 Sampling Oscilloscope (Tektronix 80E04)

This sampling oscilloscope provides comprehensive measurement capabilities from DC to 20 GHz. By digitizing the input signal, the 80E04 model was capable of achieving an equivalent sampling rate of 20 GHz. The captured waveforms were stored and analyzed in both time and frequency domains. A 3 dB matching pad is always used between the UWB device and the sampling oscilloscope. The peak and average powers were calculated using the following definitions

$$\text{Peak Power} = \frac{x_{max}^2}{50} \tag{4.1}$$

$$\text{Average power} = \text{PRF}\,\Delta t \sum_i x_i^2 \tag{4.2}$$

where x_i is the *i*th sample of the time-domain signal, x_{max} is the maximum value, Δt, is the sampling interval, and PRF is the pulse repetition rate.

Figure 4.2 depicts the time-domain signal logged by the sampling oscilloscope.

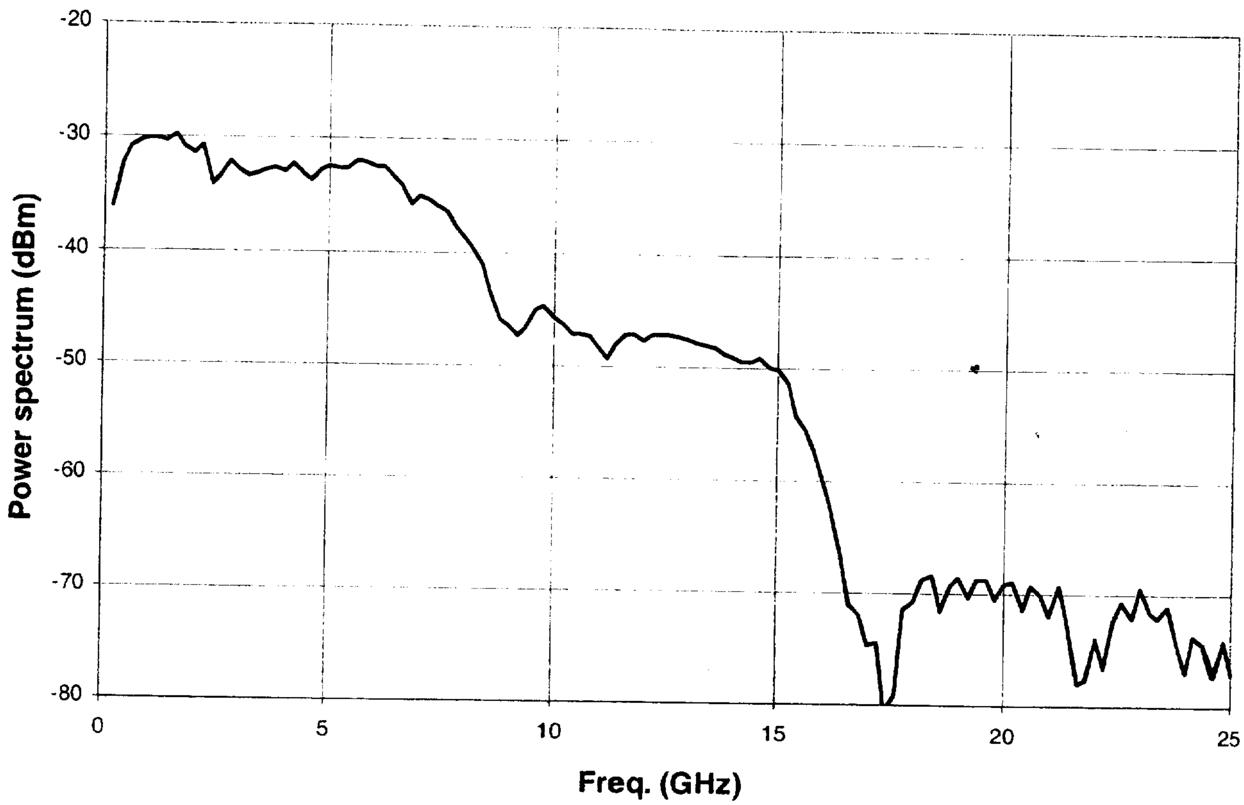

Figure 4.2: .FFT analysis of the time-domain pulse

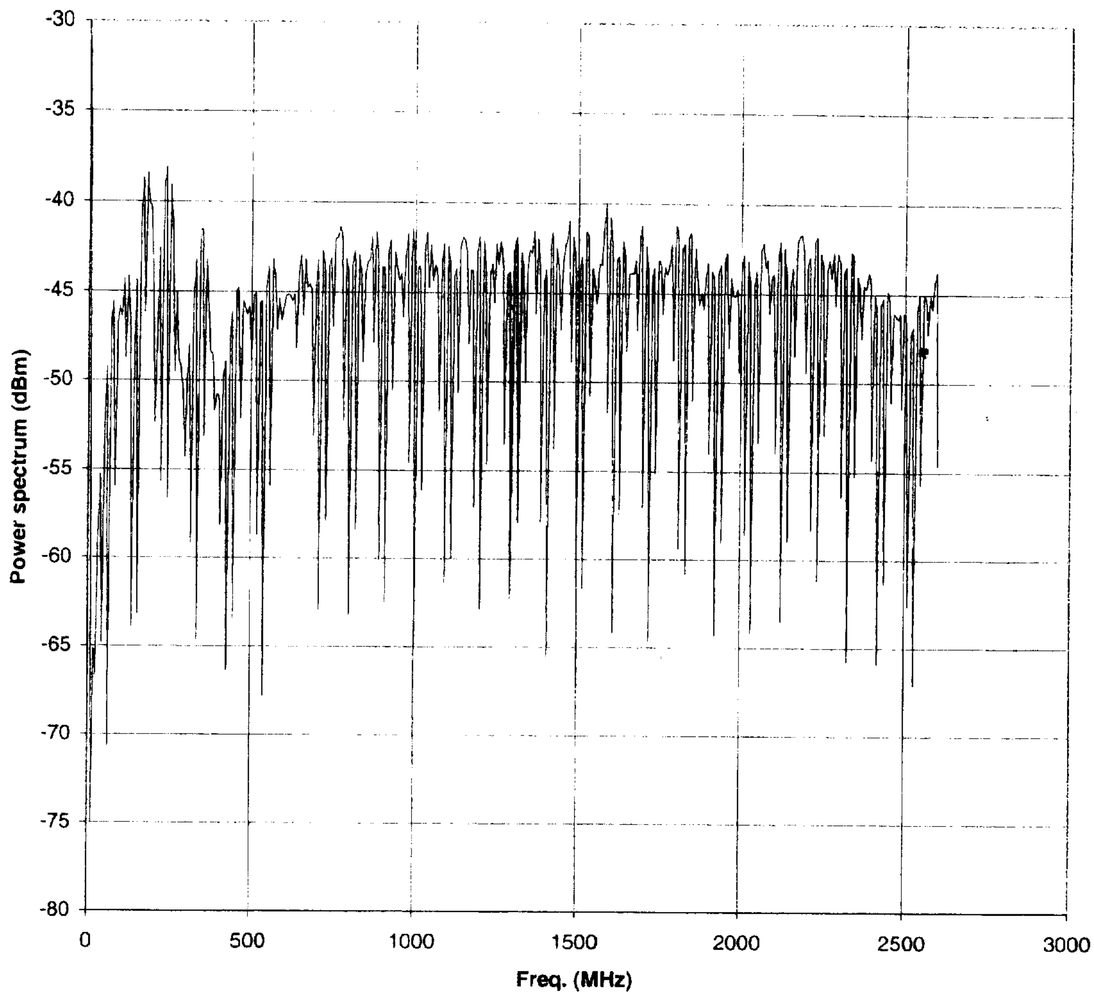

Figure 4.3: Spectrum as measured by Agilent 8563E spectrum analyzer

4.4 Test Setup

The test setup consists of a HP 8924C base station simulator, a Hyperlab HL9200 Pulse Generator triggered by a Sony/Tektronics AWG 2021 arbitrary waveform generator, and a QCP 1960 CDMA PCS phone. The other test components are shown in Figure 4.4. The forward link of the phone and the UWB device are calibrated as shown in Figure 4.5 and Figure 4.6, respectively. The phone reverse link is kept very strong to minimize the impact on forward link FER.

The results of the calibrations are as follows:

(1) The path loss between the base station simulator and the phone input is 6.35 dB (this does not include a 0.7 dB cable loss between the antenna connector and the phone LNA). All the step attenuators were set to zero.

(2) The path loss between the output of the UWB device and the input to the phone is 5.87 dB (this does not include the 0.7 phone cable loss). The step attenuator was set to zero.

A very fast sampling oscilloscope was used to capture the individual pulses directly in the time domain.

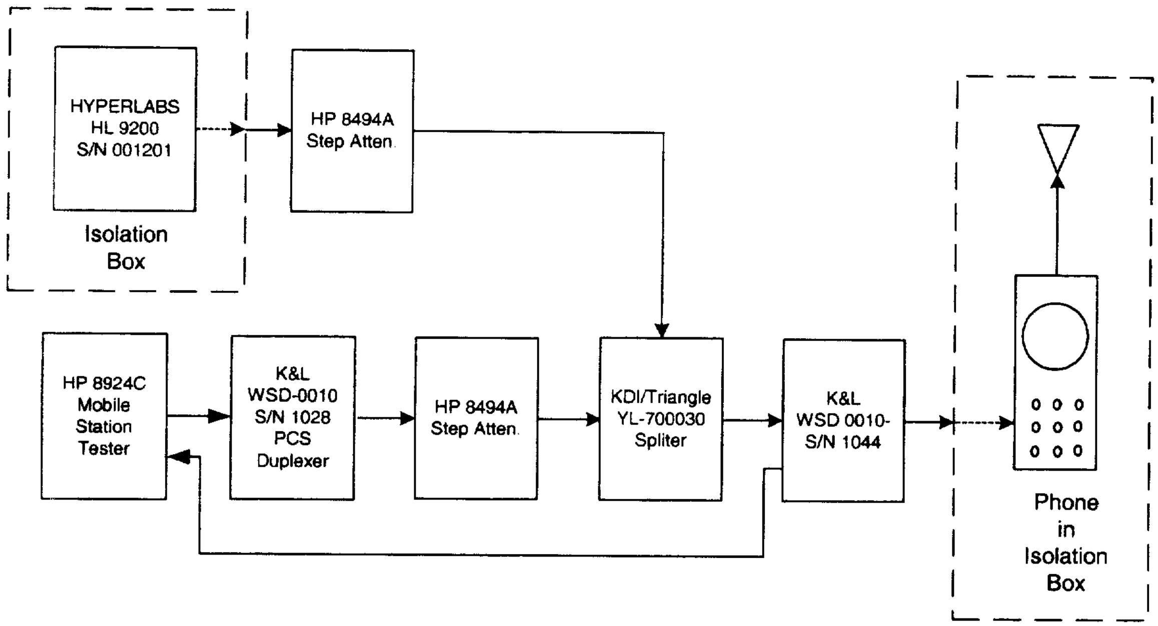

Figure 4.4: Test setup

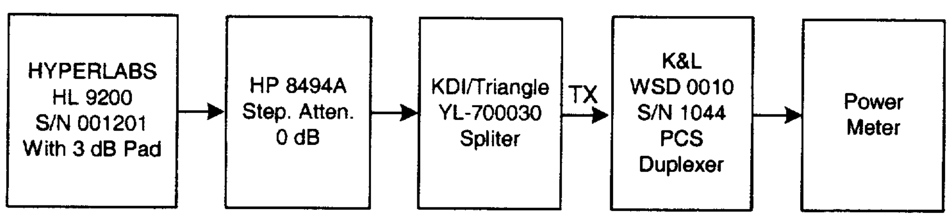

Figure 4.5: UWB link calibrations

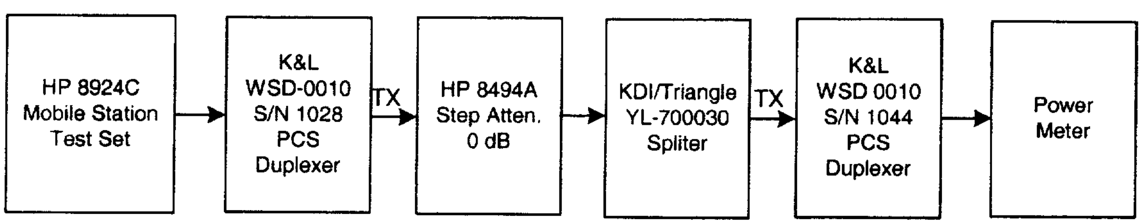

Figure 4.6: CDMA link calibrations

4.5 Measurement Procedure

All components are checked using the network analyzer to make sure that they are not frequency selective over the band of interest. After calibrating all the links, the step attenuators are used to adjust both the forward link PCS power and the UWB interference power. A full-rate frames 2-minute call is then setup using the base station simulator.

The UWB signal used in this test is pulse position modulated (PPM). The *n*th pulse is transmitted at time $T(k + \beta_n)$, where β_n is a random variable uniformly distributed over $(-\beta_{max}, \beta_{max})$, depending upon the value of the information bit.

Figure 4.7 is the measured power over CDMA channels (1.25 MHz) for different pulse repetition frequency (PRF). Most modern spectrum analyzers allow the measurement of the power within a frequency range which is called the channel bandwidth. The displayed result comes from the computation:

$$P_{ch} = \frac{B_s}{B_n}\frac{1}{N}\sum_{i=n_1}^{n_2} 10^{(P_i/10)}$$

P_{ch} is the power in the channel

B_s is the specified bandwidth (also known as the channel bandwidth),

B_n is the equivalent noise bandwidth of the RBW used,

N is the number of data points in the summation, and

P_i is the sample of the power in measurement cell *i* in dB units (if P_i is in dBm, P_{ch} is in milliwatts). Since n_1 and n_2 are the end-points for the index i within the channel bandwidth,

$$N = (n_2 - n_1) + 1$$

It is noted that a UWB signal emits a significant power over a large portion of the spectrum and generates multiple spectral lines over a very large ranges of frequencies. The HL9200 Pulse Generator Module used in the measurements is a low jitter triggerable and is triggered by a Sony/Tektronics AWG 2021 arbitrary waveform generator.

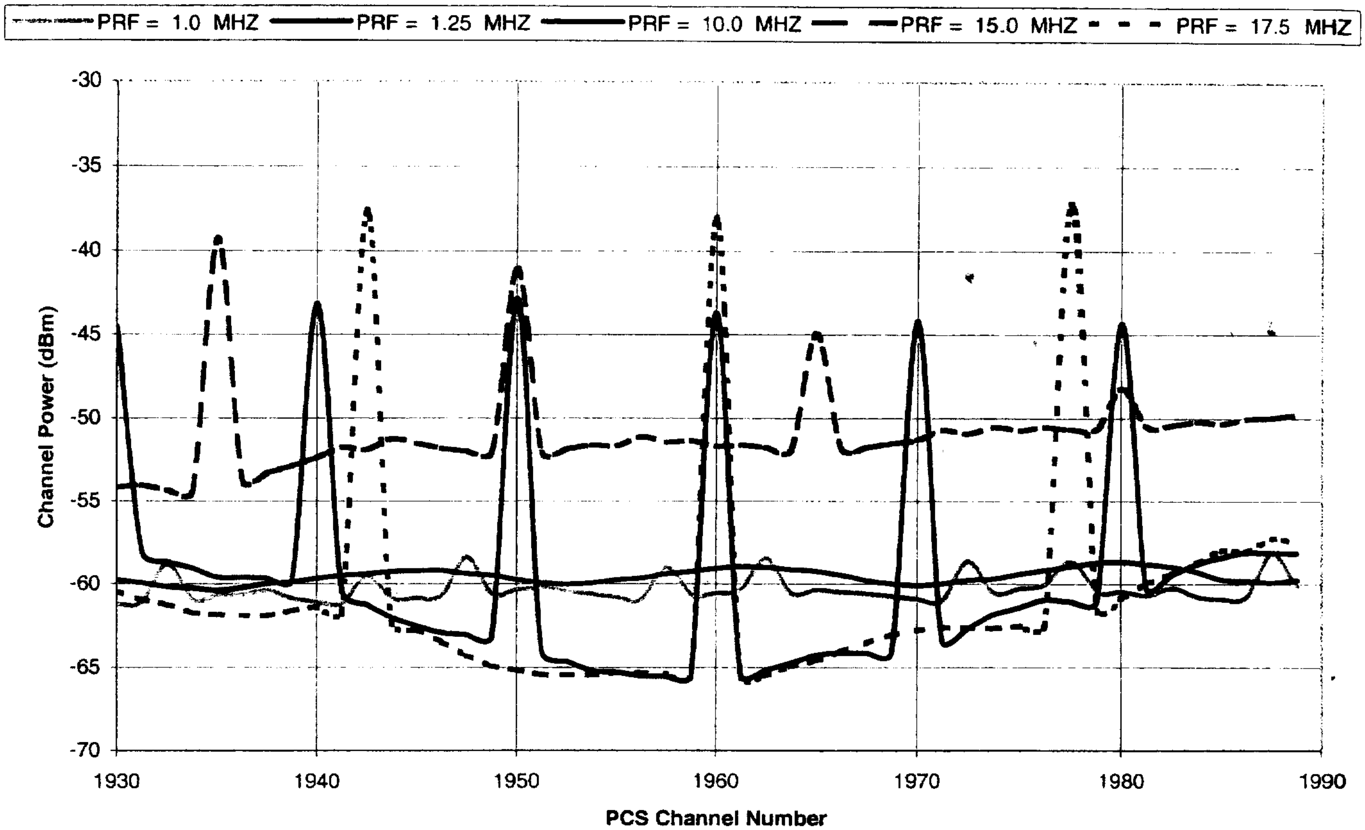

Figure 4.7: CDMA channel power at different PRFs

4.6 Time Dithering

For some UWB applications, the pulse train may be a pulse position modulated by a time-dither sequence. Time-dithering attenuates the discrete spectral line PSD component caused by the periodic pulse and introduces a continuous random noise PSD component. The effectiveness of dithering is dependent on:

(1) Distribution of dithering times
(2) The reference time of the time-dithered pulse (absolute or relative to the last pulse)
(3) Length of the time-dither sequence

QUALCOMM envisions that UWB devices will be used for short-range communication links. These devices will typically be used for providing device-to-device connectivity on an ad-hoc basis. They can be used in an office or home environment as a WLAN systems target for a wireless replacement for LAN infrastructure. In an office environment, UWB and PCS radios will typically operate simultaneously. Because

UWB uses the same band as PCS, interference to PCS phones and data devices is a concern.

4.7 Creation of the PRF vs. CDMA Channel Power Plot

The output of the UWB source was connected directly to a HP8595E spectrum analyzer. The UWB source was triggered using a waveform generated by a Tektronix Arbitrary Waveform Generator AWG2021. The clocking frequency used to create the waveform determined the Pulse Repetition Frequency (PRF) of the UWB trigger signal.

The spectrum analyzer used has a built-in function that measures CDMA channel power in a 1.23 MHz wide channel. See Agilent's application note on 1303 (Spectrum Analyzer Measurements and Noise) for details on how the spectrum analyzer produces the measurement numbers. The signal detector was set to sample detection, as the CDMA signal resembles a noise signal. The resolution bandwidth was set to 30 kHz and the video bandwidth was set to 3 MHz. The center frequency selector was set to step through the PCS band spectrum with 1.25 MHz increments.

4.7.1 Creation of the Trigger Waveform

The 3-postion dithering trigger waveform was constructed from 252,000 points using a Matlab program. There were approximately 18,000 cycles in the waveform each consisted on the average of 14 points. As this was a dithered signal, the duration of the cycle depended on the position of the next rising pulse. On the average, one out of every 14 points was a logical one while the remaining 13 points were all logical zeros and the logical one is what triggers the UWB source pulsar. The duration of the cycle calculated as follows:

Cycle period = period between two consecutive points X number of points in a cycle.

The period between two consecutive points in a cycle is set by AWG2021 clocking frequency specified to have a maximum of 250 MHz.

The PRF is then calculated as

PRF = AWG2021 clocking frequency / 14.

The PRF was then measured using an HP5334B frequency counter to insure the accuracy of the calculated PRF.

The amplitude of the signal varies between a low of 0 volts and a high of 5 volts.

4.7.2 Measurement Routine

(1) The PRF is set on the AWG2021 to one set point in the range of (1-17.5 Mhz) in steps of 1 MHz.
(2) Steps 3-5 are repeated for all PRF set points in the range in step 1 above.
(3) The spectrum analyzer's center frequency was set to a CDMA channel center frequency in the PCS Forward Link spectrum range of (1930-1990 MHz). The CDMA channels center frequencies are 1.25 MHz apart so the step size for the measurement points is 1.25 MHz
(4) CDMA channel power measurements taken 20 times and the mean recorded.
(5) Steps 3-4 are repeated for remaining CDMA channels in the PCS forward link spectrum.

Automation software was developed step through all possible CDMA channels in the PCS Forward Link spectrum (1930-1990 MHz) taking the mean of 20 CDMA channel power readings at every point in the manor described above.

4.7.3 Creation of FER Curve Points

The FER was measured by the HP8924C base station emulator having a call setup on a Qualcomm QCP-1960 phone.

4.7.3.1 Step Attenuators Calibration

The frequency response of the combination of HP8495A and HP8494A step attenuators was characterized using HP8720ES network analyzer. The attenuation accuracy of the attenuators was tested using a CW signal generator and a power meter. The attenuators were fed a 30 dBm CW signal from a Marconi Instruments 2024 signal generator at one feed end and the power was measured at the other feed end using a HP E4418B power meter for all available attenuation steps.

4.7.3.2 Measurement Steps

(1) The PRF is set on the Tek AWG2021 using one of three set points: 10, 15, or 17.5 MHz.
(2) Steps 2-7 are repeated for all PRF set points.
(3) The mobile-reported receive power is set using the HP step attenuators connected on the path between the phone and the base station emulator to one of three set points: –90, -95, or –100 dBm.
(4) Steps 5-7 are repeated for all mobile receive power set points in step 3 above.
(5) The UWB power is set using the HP step attenuators that are connected on the path between the UWB source and the phone.
(6) FER measurement counters are reset then two minutes of wait time is allowed after which the Base Station Emulator reports the number of good frames observed, the number bad frames received, and the frame error rate calculated as the ratio of the later counters.
(7) Steps 5-6 are repeated until the call drops.

Use of the HP E4418B Power meter and 8481D Diode Power Sensor

The power meter was used to measure path loss between the UWB power feed point and the phone receive point. Measuring the path loss entailed feeding one end of the path with a CW signal from a signal source and measuring the power the other end of the path with the power meter.

It was also used in conjunction with a CW signal source in the same manor as above to measure the path loss between the Base Station Emulator feed point and the phone receive feed point.

4.7.4 Use of the HP 8595E Spectrum Analyzer

The spectrum analyzer was used to measure the UWB power in a single CDMA channel since that was the power measurement of interest to these tests. The power meter could not be used to measure the power as the power meter measures all power in a band that is approximately 18 GHz wide. It was also used to measure the received UWB power at the phone feed point. The path loss between the UWB source feed point and the phone receive feed point is cross-checked with the path loss measurement made with the power meter.

The spectrum analyzer was also used to measure the CDMA power received at the phone feed point from the Base Station Emulator. This value was cross-checked with path loss measured with the power meter and CW signal source.

The spectrum analyzer was also used in measuring the noise introduced by a wide band AWGN source in a single CDMA channel in the same manor described above.

5. Impact on PCS Phones

Figure 5.1 depicts the degradation in frame error rate as a function of UWB power.

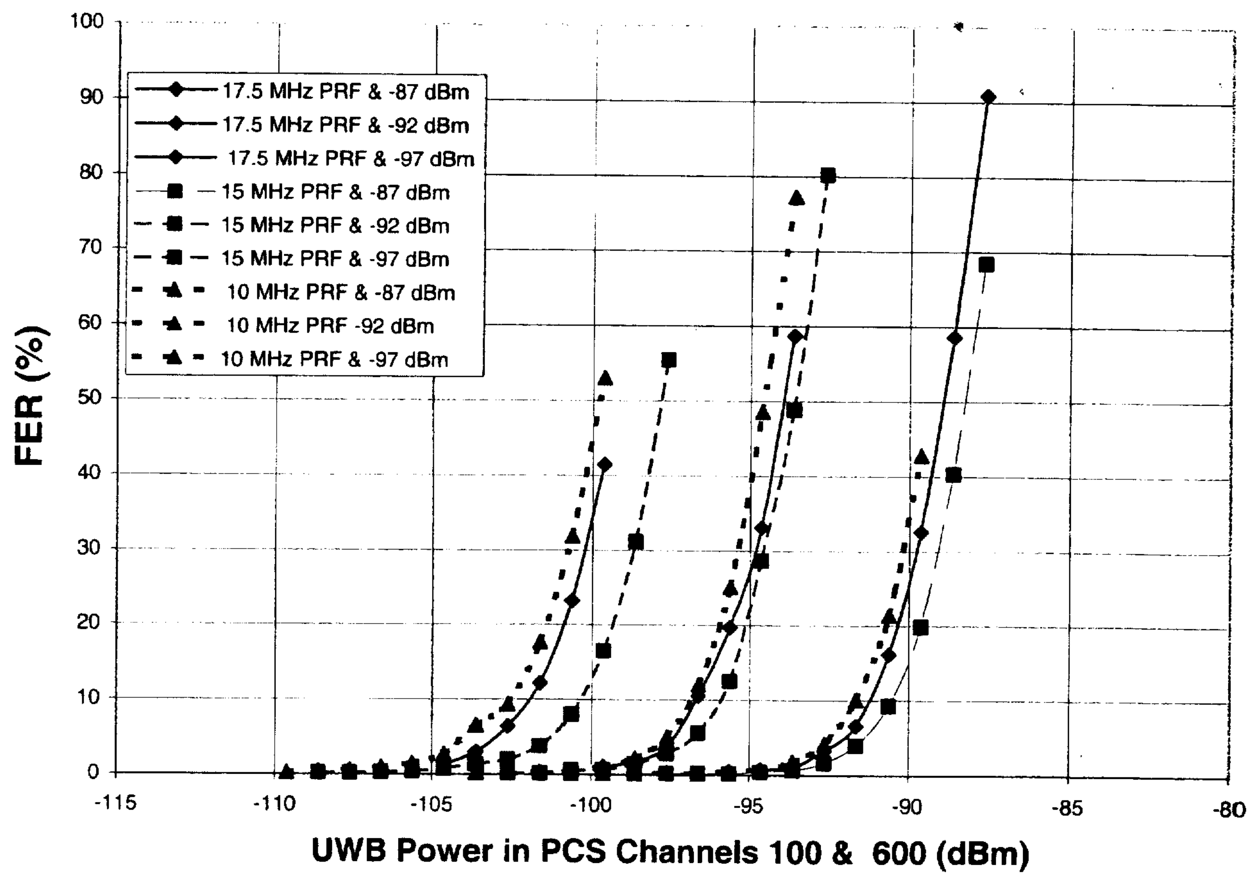

Figure 5.1: Degradation in FER as a function of UWB power

6. Conclusion

The FCC must not proceed with the rulemaking before sufficient testing and analyses conclusively prove there will be no interference to PCS phones. The close proximity of UWB devices to wireless phones may degrade their equivalent noise figure to the extent of rendering their operation useless, especially in marginal coverage areas.

In addition, QUALCOMM is concerned that the aggregate effect of many of these UWB devices will potentially degrade the operation of PCS phone during E9-1-1 calls in the following ways:

(1) First, the UWB devices could cause a loss of GPS signals for the wireless phones by reducing the signal-to-noise ration of a given satellite to such an extent that the GPS receiver can no longer de-correlate the given satellite signal and hence reduces GPS coverage.
(2) Second, such reduction in the signal-to-noise ratio would cause higher errors in range measurements provided by the receiver. These errors will propagate through the GPS receiver position location algorithms and cause the GPS to provide incorrect positioning information.
(3) Third, UWB signals could degrade the GPS receiver acquisition time, resulting in longer response time. The NPRM states that it is "vitally important" that critical safety systems operating in the restricted frequency bands, including GPS operations, are protected again interference.

The Commission should not act in this proceeding until it has sufficient testing and analysis of the potential for interference from UWB devices. QUALCOMM urges the Commission not to modify the Part 15 rules until all the questions regarding the impact of UWB devices on other wireless services are fully and thoroughly answered.

QUALCOMM is also concerned about the proliferation of UWB devices. With the proliferation of UWB devices, collocation with CDMA based devices will become increasingly likely. Large numbers of UWB interference sources can significantly raise the overall noise floor of wireless receivers. This noise level has a significant effect on wireless communications system range and GPS performance. The proposed UWB rule that allows the operation of UWB in the 2 GHz band will have harmful impact on the normal operation of CDMA wireless devices in voice, data and GPS modes. The proposed introduction of time-domain based UWB technology in the frequency domain poses serious and complex technical issues that are not fully understood. In this regard, it is important that the FCC ensure that any licensed radio services are protected against harmful interference. This protection should apply to cellular, PCS, and future third-generation bands.